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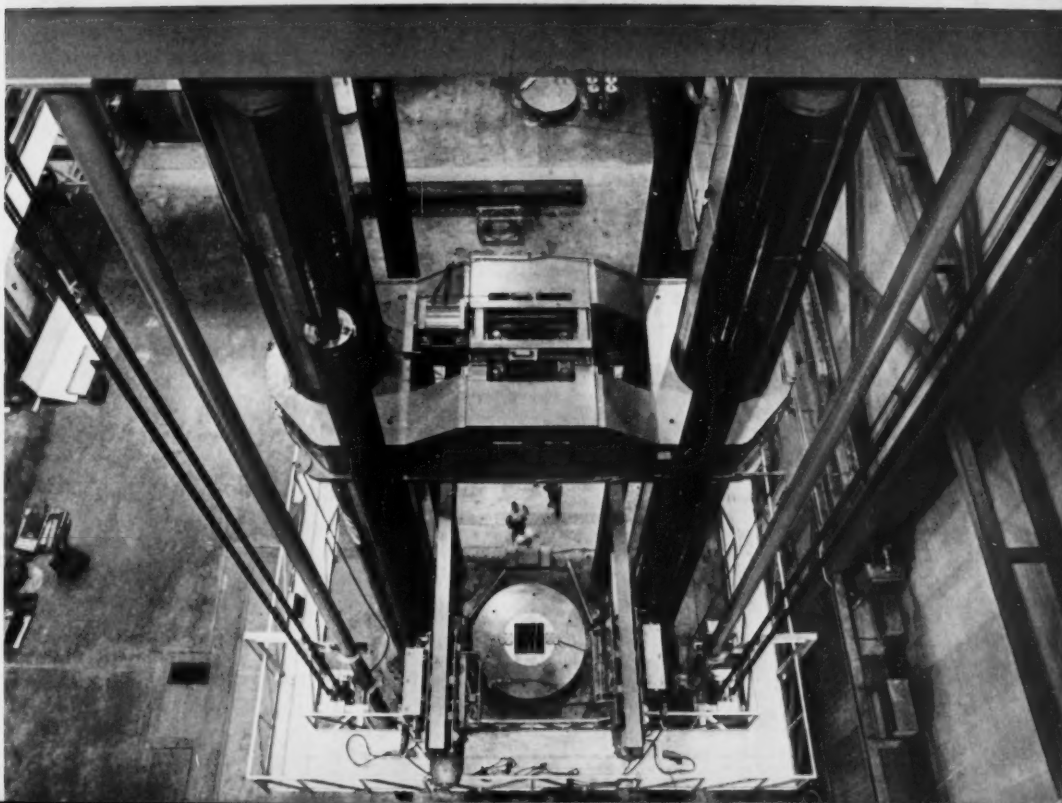
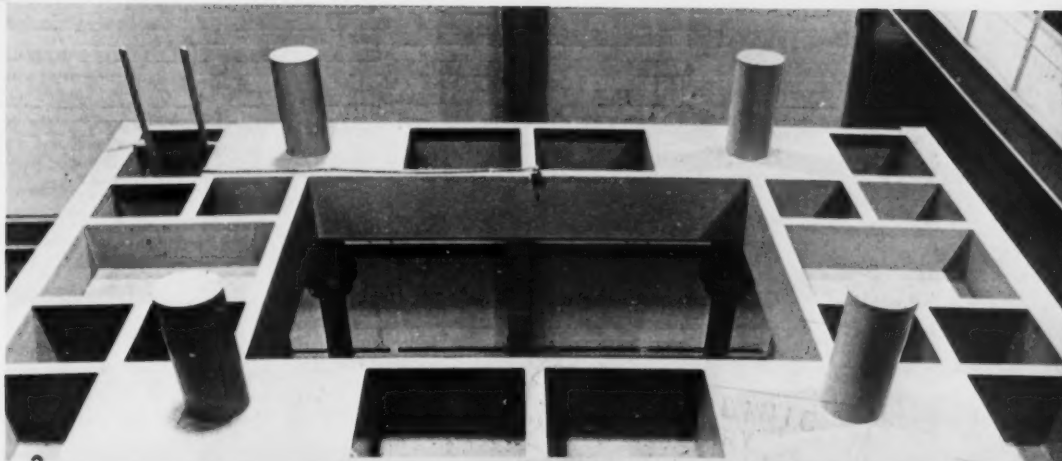
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**NATIONAL BUREAU OF STANDARDS**

# **Technical News Bulletin**



**UNITED  
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COMMERCE**

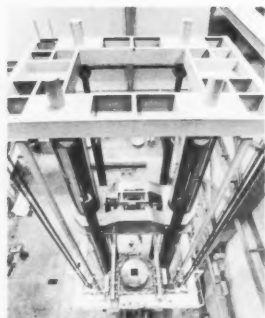
NATIONAL BUREAU OF STANDARDS

# Technical News Bulletin

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COVER: Wide-angle view from above the 12-million pound testing machine. See page 274 for further details.

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# COULOMETRIC DETERMINATIONS OF ATOMIC WEIGHTS

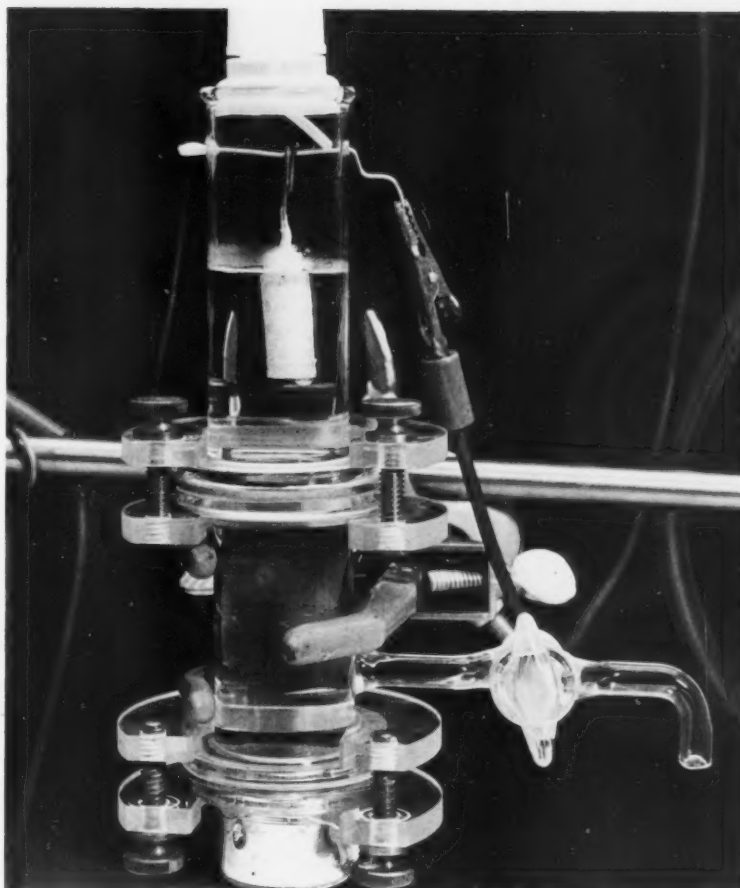
FOR MANY YEARS SCIENTISTS HAVE ATTEMPTED TO ESTABLISH MORE ACCURATE VALUES FOR ATOMIC WEIGHTS. As atomic weights form the basis for many formulations in all phases of chemistry, the accuracy of these values is of obvious importance. Basing their studies on Faraday's Law, G. Marinenko of the Bureau and R. T. Foley of American University have coulometrically determined the atomic weight of zinc to be  $65.377 \pm 0.003$ .<sup>1</sup>

The currently accepted value is  $65.38 \pm 0.01$ . This value was adopted recently by the International Union for Pure and Applied Chemistry (IUPAC) in recognition of this and other studies.

The coulometric methods of chemical analysis are based on the measurement of the amount of electricity used in an electrochemical reaction. The law of definite propor-



George Marinenko adjusts the cell prior to the electrochemical dissolution of the zinc-amalgam anode. A constant current of known magnitude is passed through the cell for a precalculated period of time sufficient to produce a change in mass of the anode roughly equivalent to two grams.



Coulometer used in the determination of the atomic weight of zinc. The weighed zinc-amalgam anode is suspended above a mercury pool cathode. A porous membrane filter inserted under the amalgamated anode showed no fall-off during the electrochemical dissolution.

tions is valid for reactions induced by the passage of electric current through an electrolytic cell; in this particular application, the passage of two faradays\* of charge through the cell will dissolve one mole of

zinc. Weighings were made of a zinc-amalgam electrode before and after electrolysis by a measured quantity of electric current. Knowledge of the weight loss associated with a measured charge

\*The value of the faraday used in this study was 96 486.70 coulombs/mole.

Continued on p. 277

# COMPUTER AUTOMATES CALIBRATION OF ACCELEROMETERS



*James Pollard installs an accelerometer, sent to the Bureau for calibration, atop the table of a vibration exciter. This type of exciter, which was developed at the Bureau, gives a flat response with little undesirable transverse motion.*

A NEW COMPUTER-CONTROLLED CALIBRATION SYSTEM has quartered the time required to calibrate an accelerometer, improved the measurement quality, and significantly reduced the laboratory's backlog. The system is controlled by a small, dedicated computer that performs all switching and setting operations and automatically records accelerometer response.<sup>1</sup> B. F. Payne, of the vibration laboratory, designed the system to speed the calibration operation, increase the quality and quantity of measured data, reduce tedious work and errors, and make possible more detailed analysis of data.

## ACCELEROMETER CALIBRATIONS

The Bureau has calibrated vibration pickups for industry and other laboratories on a regular basis for more than 15 years. This was once done with conventional commercial equipment — an electrodynamic vibration exciter having an armature supported vertically by flexible metal supports. These flexures and the complexity of the structure often resulted in instability at some frequencies, distortion, and unwanted transverse motion of the armature. The Bureau attacked this situation with a program of exciter redesign and improvement over nearly a decade. Transverse motion was greatly reduced and improved

performance obtained over a wider frequency range with the introduction at the Bureau of ceramic armatures moving in air bearings and permanent magnet fields.<sup>2</sup> Despite this improvement, accelerometer calibration still required tedious work by highly trained operators. An automated system was needed that would perform accelerometer calibrations automatically without the possibility of error inherent in a manual calibration. Commercial calibration systems available at the time of this system design drove exciters with a signal that was swept in frequency over the range of interest. This is ideal for a "quick look" calibration, but it may introduce distortion and uncertainty into the calibration. The NBS automated system, on the other hand, uses a steady state calibration process at selected frequencies and acceleration levels.

The need for a faster, more accurate accelerometer calibration system was made more acute by the steadily increasing number of accelerometers to be calibrated. The Department of Defense's Calibration Coordination Group, a regular user of NBS calibration services, was aware of this need and supported development of a new system to update NBS's calibration capabilities.

#### NEW SYSTEM

The new calibration system consists, essentially, of two vibration exciters on an isolation air-table, a digital oscillator and power amplifier, the computer, and peripheral equipment for instructing the system and for plotting and recording data.

The Dimoff-type exciters used supply a motion containing less than 1% harmonic distortion over most of their useful frequency range, making possible calibration uncertainties of not more than  $\pm 1\%$  from 10 Hz to 1 kHz and  $\pm 2\%$  from 1 kHz to 3 kHz. Data reported above 3



NBS time sharing computer terminal produces a printout of the response curve of a pickup calibrated on the computerized calibration system. William Stull inspects this output.



Automated accelerometer calibration system consisting of, from left to right, two Dimoff-type vibration exciters on a stabilized platform, component interconnection panel, system components, magnetic tape drive, the computer, and the keyboard terminal for instructing the system and obtaining printout of test pickup response. B. F. Payne is at the keyboard.

kHz are obtained from a system using photometric interferometry to determine dynamic displacements.

The computer has a 16,000-byte memory, which is divided into 16-bit words, and 16 general registers of 16 bits each. Memory cycle time is 1.8  $\mu$ s and add instruction time is 34  $\mu$ s. The computer software is written in a machine language for controlling machine functions and also for setting relays and operating devices interfaced to the computer.

#### SYSTEM OPERATION

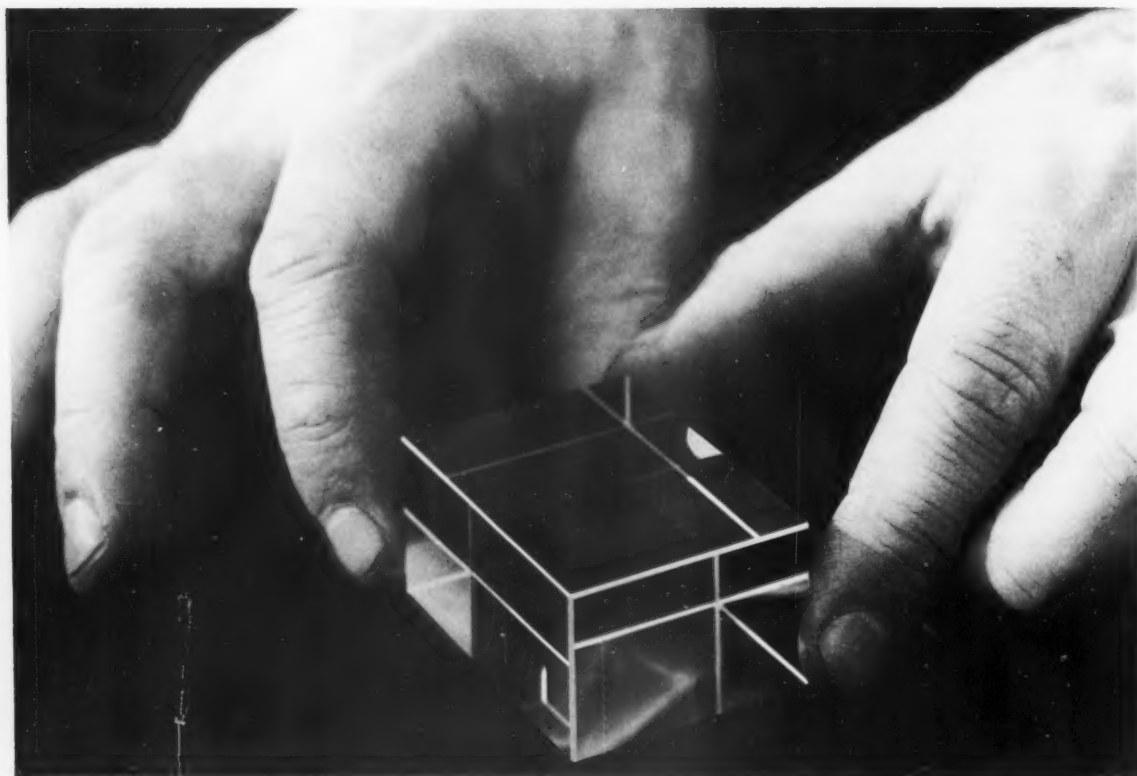
The computer is instructed in performing a calibration by keyboarding the directions into its terminal or, for often-repeated

calibrations, by reading the calibration parameters into the computer from a punched paper tape or magnetic tape. These data are retained in the data block for the calibration; they include, for each exciter: frequency, the desired acceleration level, the oscillator voltage, and relay-setting codes for the circuit configuration desired.

The frequency entry sets the oscillator to the discrete frequency desired and the voltage entry sets the oscillator output amplitude. The output of the reference accelerometer mounted in the vibration exciter is then sampled (via an ac-to-dc voltage converter) for comparison

*Continued on p. 283*





*The velocity of sound in this specimen of borosilicate optical crown glass was determined by measuring how long it took a pulse from a vibration transducer to travel across the specimen and be reflected back to the transducer. This specimen has parallel faces separated by 1, 1½, and 2 inches.*

## SOUND SPEED IN SOLIDS

STUDIES ON MEASURING THE SPEED OF SOUND in solids have led to a technique which increases the accuracy of such measurements. Thomas Proctor, Jr., studied sources of error in this measurement and found that reflections within the bond between the sound transducer and the solid degrade signals reflected within the solid. By dimensioning the bond so that spurious bond reflections are delayed past the time of measure-

ment he improved measurement accuracy to better than 50 parts per million.<sup>1</sup> This improvement is of significance to scientists measuring sound velocity in laboratories and to engineers designing delay lines, which are widely used in radar and sonar systems.

### STUDYING PROPAGATION IN SOLIDS

The speed with which sound travels through solids is commonly

measured by placing a vibration transducer in contact with one face of a parallel-ended specimen of the material. The transducer sends out a pulse that is reflected within the sample and returns to be received by the same transducer (acting as a receptor). The pulse is then presented on a known time base by an oscilloscope. If two pulses having an adjustable separation are sent through the material and the delay adjusted so that the first

reflection of the second pulse coincides with the second reflection of the first pulse, the difference in starting time of the two pulses is the time required for a pulse to traverse the sample and return.

Under the best conditions this technique yielded velocity values constant only within 200 ppm in aluminum blocks cut to varying lengths from a single polycrystalline bar. That the inconstancy was apparently due to heterogeneity of density within the sample material is suggested by the fact that variations in the speed of sound measured in silica were found to correspond roughly to variations in internal stress and density observed with a polarimeter. A search was launched for a better material, one of sufficient uniformity for measurement variations to be attributed to the method.

The search ended with borosilicate optical crown glass BSC 517/645, a material known to have high optical and acoustical uniformity,<sup>2</sup> which had been manufactured at the Bureau. This material offered as a bonus a temperature coefficient of velocity near zero. Variations in sound velocity measured in a single sample of this material for round trips over paths of 1, 1.5, and 2 inches yielded variations smaller than the measurement threshold.

#### APPRAISING MEASURES OF SOUND SPEED

The study disclosed that more accurate measurements of the time of flight within the sample were obtained as transducers of increasing resonant frequency were used. Further improvement in accuracy was achieved by adjusting the delay between pulses for coincidence earlier in the rise of the two pulses. In doing this Mr. Proctor found that the more-often-reflected pulse was shaped differently than the once-reflected second pulse, the former

having a more rapid rise. He studied the difference by obtaining time difference factors,  $\Delta\tau$ , from photographs of the front edges of signals on successive reflections. To correct for wavefront change on reflection he added the appropriate time correction factor to each measure of the delay time for pulse coincidence. This correction factor,  $\Delta\tau$ , has greatly improved measures of the velocity of sound through solids.

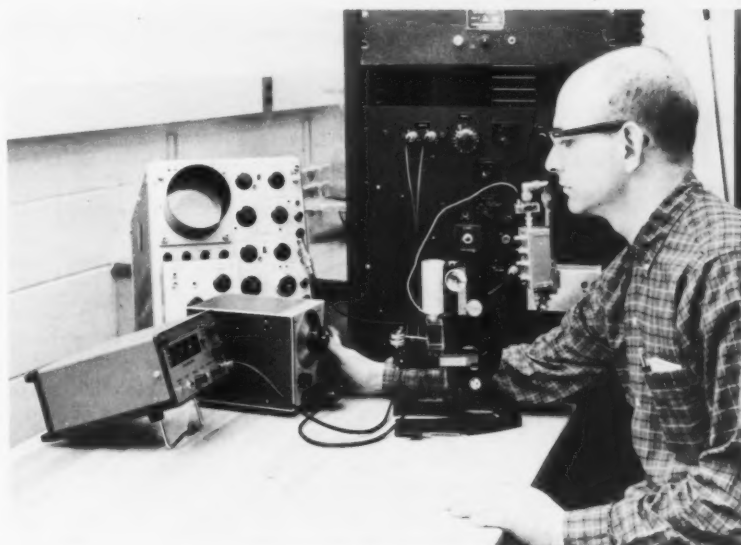
It was also found that the pulses reflected from the far wall were not the only ones present; arriving later were pulses delayed by having been reflected within the bonding material between the transducer and the specimen. These can be seen on the oscilloscope as weaker pulses following the primary one by the duration of their extra travel. These multiple reflections confuse coincidence settings because they change the shape of the returned pulses. The effects of multireflections associated with the bond were eliminated by increasing the bond

thickness until these unwanted reflections were removed from the rising slope of the wanted pulse.

In this work water was used as the bonding agent between transducer and specimen. Bonds of several  $\mu\text{m}$  are thick enough for the samples used to insure that the leading edge of the pulse will be undistorted. The bond gap is varied by mounting the transducer on a microscope mechanism so that it can be raised and lowered controllably. The gap is adjusted so that the received pulses observed on an oscilloscope are positioned with no intrabond reflections occurring during the rise of the desired pulse. By correcting for all the different errors mentioned, sound speed values constant to within 50 ppm can be realized with a transducer resonant at 18 MHz.

<sup>1</sup> Proctor, T. M., Jr., Sound speed measurements in solids; absolute accuracy of an improved transient pulse method, *J. Res. Nat. Bur. Stand. (U.S.)*, **75C** (Eng. and Instr.), No. 1 (Jan-Mar. 1971). Order by SD Catalog No. C13.22/sec.C:75.

<sup>2</sup> Forsythe, W. E., *Smithsonian Physical Tables* (1954, the Lord Baltimore Press).



Thomas Proctor, Jr., examines oscilloscope presentation as he increases the separation of a vibration transducer and a specimen. This gap will be adjusted so that no undesired signals occur during the rise of the desired one, for better measurements of the speed of sound in the specimen.



*John Nichols of the Gaithersburg-Washington Grove, Maryland, Fire Department puts on a typical firefighter's turn-out coat. Such coats are being investigated at NBS in an attempt to reduce severity and number of injuries to firefighters.*

## FIREFIGHTERS' TURN-OUT COATS

THE BUREAU, UNDER ITS RESPONSIBILITIES SPECIFIED BY THE FIRE RESEARCH AND SAFETY ACT,<sup>1</sup> is investigating firefighters' coats. The goal of this research is increased protection and comfort for the fireman while maintaining his functional ability. Although this particular investigation is aimed mainly at the turn-out or bunker coat, it is anticipated that the total program will yield useful data on the entire protective clothing

system of firefighters as well as their breathing apparatus.

Statistics show that firefighting is among the most hazardous of occupations. All too often, during the course of extinguishing fire, injuries and deaths occur by exposure to smoke and toxic gases, overexertion, extreme temperatures, falls, and blows from flying or falling objects. The protective clothing, helmet, boots, gloves, and breathing apparatus are the firefighter's main

protection against injury and death. For this reason, the Bureau has undertaken the investigation of firefighters' coats to identify requirements they should meet, to examine existing tests or develop new tests to determine if these requirements are met, and to establish performance criteria (specifications). The need for such an investigation was demonstrated by preliminary NBS test results which show that some of the most commonly used firefighters' coats cannot pass the flammability standard proposed for children's sleepwear!

Many factors besides flammability are also being considered. For example, the coat should be resistant to tearing by jagged objects, water penetration, and radiant heat; it should provide warmth in cold weather but still allow mobility; it must be easy to put on; and the interfaces between the coat and other items of clothing must be carefully designed.

While there are tests available to determine some of these properties in the laboratory, a complete evaluation by existing procedures is impossible. For example, when a fireman is carrying breathing apparatus, it is exerting pressure on his clothing at a particular area, usually on the back and shoulders. What is the effect of this pressure on the coat's resistance to heat? Could padding reduce injuries due to falls and flying objects and still allow the firefighter to function as effectively? When does wear reduce the effectiveness of the coat to the point that it should be discarded?

For answers to these and other  
*Continued on p. 286*



# ACCURATE VAPOR PRESSURE EQUATION FOR WATER

An equation<sup>1</sup> for calculating the vapor pressure of pure water over the temperature range from 0 to 100°C has been derived by A. Wexler and L. Greenspan of the Humidity Section. This equation yields computed values agreeing to within 7 ppm with the precise measurements at seven temperatures in the range 25 to 100°C recently reported at NBS by H. L. Stimson.<sup>2</sup> Such an equation is

essential in establishing and maintaining humidity standards, in calibrating hygrometers, in making humidity measurements, and in steam technology. The equation is also important in the fields of meteorology, air conditioning, chemical thermodynamics, and in vapor pressure measurements of organic liquids.

The vapor pressure measurements were obtained with the

steam boiler and precision manometer formerly used at NBS to calibrate platinum resistance thermometers. The measurements have an estimated standard deviation of 20 ppm or less except at 25°C where the estimated standard deviation is 44 ppm.<sup>2</sup> Although formulations exist that give vapor pressures in reasonably good agreement with these measure-

*Continued on p. 282*

Saturation vapor pressure over water (IPTS-48)

| Temperature<br>deg C | 0.0     | 0.1     | 0.2     | 0.3     | 0.4     | 0.5     | 0.6     | 0.7     | 0.8     | 0.9     |
|----------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|                      | pascals | pascals | pascals | pascals | pascals | pascals | pascals | pascals | pascals | pascals |
| 0                    | 610.752 | 615.205 | 619.686 | 624.196 | 628.736 | 633.304 | 637.902 | 642.529 | 647.187 | 651.874 |
| 1                    | 656.591 | 661.338 | 666.116 | 670.924 | 675.763 | 680.633 | 685.534 | 690.466 | 695.429 | 700.425 |
| 2                    | 705.451 | 710.510 | 715.601 | 720.724 | 725.879 | 731.068 | 736.289 | 741.542 | 746.829 | 752.150 |
| 3                    | 757.504 | 762.891 | 768.313 | 773.768 | 779.258 | 784.782 | 790.341 | 795.934 | 801.563 | 807.227 |
| 4                    | 812.926 | 818.660 | 824.431 | 830.237 | 836.079 | 841.958 | 847.873 | 853.825 | 859.814 | 865.840 |
| 5                    | 871.903 | 878.004 | 884.142 | 890.318 | 896.533 | 902.785 | 909.076 | 915.406 | 921.775 | 928.183 |
| 6                    | 934.630 | 941.117 | 947.643 | 954.209 | 960.816 | 967.462 | 974.150 | 980.878 | 987.647 | 994.457 |
| 7                    | 1001.31 | 1008.20 | 1015.14 | 1022.11 | 1029.13 | 1036.20 | 1043.30 | 1050.45 | 1057.64 | 1064.87 |
| 8                    | 1072.15 | 1079.47 | 1086.84 | 1094.25 | 1101.70 | 1109.20 | 1116.75 | 1124.34 | 1131.97 | 1139.65 |
| 9                    | 1147.38 | 1155.15 | 1162.97 | 1170.83 | 1178.75 | 1186.71 | 1194.71 | 1202.77 | 1210.87 | 1219.02 |
| 10                   |         | 1225.46 | 1233.76 | 1242.10 | 1250.49 | 1258.93 | 1267.43 | 1275.98 | 1284.57 | 1293.22 |
| 11                   |         |         | 1299.45 | 1307.93 | 1316.46 | 1325.04 | 1333.67 | 1342.35 | 1351.07 | 1359.84 |
| 12                   |         |         | 1367.55 | 1376.29 | 1385.07 | 1393.90 | 1402.78 | 1411.71 | 1420.68 | 1429.70 |
| 13                   |         |         |         | 1438.77 | 1447.90 | 1457.08 | 1466.31 | 1475.58 | 1484.90 | 1494.27 |
| 14                   |         |         |         |         | 1503.69 | 1513.03 | 1522.42 | 1531.86 | 1541.35 | 1550.89 |
| 15                   |         |         |         |         |         | 1560.48 | 1569.96 | 1579.49 | 1589.07 | 1598.70 |
| 16                   |         |         |         |         |         |         | 1608.37 | 1617.91 | 1627.50 | 1637.14 |
| 17                   |         |         |         |         |         |         |         | 1646.24 | 1655.97 | 1665.75 |
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# SCIENCE, TECHNOLOGY, AND THE ECONOMY

*Statement by Secretary of Commerce Maurice H. Stans before the Subcommittee on Science, Research and Development House Committee on Science and Astronautics, July 27, 1971.*

My interest in appearing before this Committee is to discuss the role of technology insofar as it relates to our economic development and particularly as it relates to our international commercial relationships.

This is most clearly evident from a review of our trade position, which is undergoing a very critical rate of change.

I will attempt to demonstrate to the Committee that technology may be a key factor in developing a solution to the emerging unfavorable trade balance.

## *Introduction*

For nearly a century this country has enjoyed healthy surpluses in its international trade balance. Positive balances have covered deficits resulting from tourism, defense, and foreign investment, and have accounted for substantial employment for many Americans. Recent

events, however, should cause us to lose any complacency we might have acquired over the years. American manufacturers now find it increasingly difficult to compete in the world market. Imports are rising dramatically, faster than exports, with a sharply negative impact on both the balance of payments and domestic employment levels.

No single answer fully explains why we are now facing these problems. Our international trade position is affected by a variety of economic and institutional factors such as:

- inflation at home and abroad
- foreign exchange rates
- trade promotion
- tariffs
- quotas and other import restrictions
- nontariff trade barriers
- export credit
- domestic wage levels, and
- technological development.

For obvious reasons we can do very little if anything to alter some of these factors. I doubt, for example, anyone seriously would suggest reducing United States wage levels.

In some other areas, such as tariffs, nontariff barriers, export credit, exchange rates, and trade promotion, we are taking steps to obtain outcomes more favorable to us. These efforts are important and are being pursued vigorously. Nonetheless, it must be recognized that success in many of these areas requires decisions by other governments, a process that is both time consuming and not within our control.

The major element which we can influence decisively for the long run is the level of technological development. It may be our only hope of maintaining a future trade position adequate to support our balance of payments in the years to come.

In the presentation that follows, I intend to concentrate on this area not because it is the sole answer to the trade problem but because it is a vital part of the answer and because I am convinced that we can do something about it.

## *Background*

For a number of historical reasons, technology has been one of the cornerstones of the United



States economy. In the 19th and 20th centuries the United States was a labor-scarce market. This made American wages generally higher than other nations and tended to make American prices less competitive in the world market. Ways had to be found to make up for both scarce labor and resulting higher product prices. Our answer was to develop and use processes and equipment which would increase the productivity of the American labor force. In brief, technological advances had to be created to compensate for our higher domestic wages.

During the 19th century the

*"—the level of technological development—may be our only hope of maintaining a future trade position adequate to support our balance of payments in the years to come."*

productivity of the United States labor force caught up with and passed all European competitor nations. The natural forces of the economy shifted laborers from low-productivity farming to high-productivity industry as increasingly sophisticated machines and processes were applied to industry. As a result, in 1876 the United States recorded its first favorable trade balance.

Throughout the first half of the



20th century. United States productivity growth rates surpassed those of Europe. Within the last two decades, however, the situation has been reversed. Since 1950, European and Japanese productivity growth rates have been higher than ours. This reversal has been achieved by a determined effort by them to accelerate technological progress and to make it an engine of economic development.

While United States technological development has not been stagnant, our competitors have been making greater relative efforts and are in effect catching up. Western Europe and Japan are narrowing the technology gap. They have increased R&D expenditures substantially and their increases in productivity over the last few years have far outpaced ours. The result is that American producers are finding it hard to hold their own against foreign manufacturers at home and abroad.

The purpose of this presentation is to illustrate the dimensions of the problem and to show the possible roles that Government might assume in assisting American industry to enhance the Nation's technological level in a vastly more competitive world economy.

The first consideration in this is to review the evidence relating to our trade decline and the relationship between that trade decline and the state of our technology compared to that of our competitors.

### *Balance of Trade*

The balance of trade measures the competitive position of products in the world market. The United States overall balance of trade in recent years has deteriorated from surpluses of \$5-\$7 billion in the early 60's to \$1-\$2 billion levels since 1967. In 1971 the trade surplus may disappear altogether, for the first time since 1893.

In order to identify more closely

the relationship between technology and trade, we have broken down trade balances into categories of higher and lower technological intensity: (1) agricultural products, (2) raw material (minerals, oil, etc.), (3) low-technology manufactures (such as textiles, iron and steel, footwear), (4) high-technology manufactures (such as computers, aircraft, automobile products).

The following trends have emerged:

- (a) agricultural products show a small but fluctuating surplus;
- (b) raw materials have a large and persistent deficit, one that is likely to grow;
- (c) the major trade losses have occurred in low-technology products. From 1951-1955 the United States showed an average annual surplus of \$1.8 billion in these products. Deficits started in 1958 and by 1965 a deficit of \$2.9 billion was realized; by 1970 this deficit more than doubled to \$6.1 billion. It will continue to increase.
- (d) the increasing deficit in low-technology products, plus the chronic deficit in raw materials, has been offset by sizeable but stable surpluses in high-technology products. A surplus of \$9.1 billion was realized for these products in 1965; minimal growth (perhaps none if inflationary factors are considered) occurred between 1965 and 1970.

Most of the new imports in high technology products have been from the more developed competing nations. With the exception of 1970, recent United States trade surpluses with Western Europe in high-technology products have declined. Our surplus with Canada has also dwindled, largely because of an automotive agreement. The United States had a deficit of \$0.1

billion in such trade with Japan in 1965; by 1970 the deficit had grown to \$1.1 billion.

### *Productivity*

An indicator of trends in the Nation's technology position is the rate of productivity growth compared with other developed countries. Productivity growth involves the measurement in the changes of output per unit of labor input.

Historically, United States productivity and productivity growth far outpaced other countries mainly because of large scale import of capital and foreign technology, immigration of skilled adult manpower, growth in markets, high wages which induced labor-saving devices, innovative spirit, lack of rigid traditions and comparatively low war losses. From 1870-1950 the United States rate of productivity growth exceeded Europe by 60% and Japan by 70%. Starting in 1950, the situation was reversed, and United States productivity growth now lags well behind Europe and Japan.

From 1950-1965 our productivity growth rate trailed Europe by 35% and Japan by 60%. The trend since 1965 shows an even more rapid relative decline: United States rates trailed Europe by 60% and Japan by 84%. These differentials in rates result both from unprecedented levels of productivity growth in Europe and especially in Japan, and from declines in United States productivity growth (1965-1969) which was only 1.7% compared with 4.5% in Europe and 10.6% in Japan.

### *Factors in Loss of Technology Advantage*

The global indicators, balance of trade and comparative productivity growth rates, indicate a relative decline in United States technological strength. Some of the factors underlying this decline are: (1) the accelerated worldwide transfer of ex-



isting technology, (2) relative lower United States investments for civilian R&D and capital equipment than foreign competitors, (3) the growth of foreign government incentives, and (4) increasing cost and risks of major technology breakthroughs, often beyond the capacity of individual companies.

### *Worldwide Transfer of Existing Technology*

There has been a proliferation of arrangements whereby United States and foreign technology have been exchanged between countries under licensing arrangements, joint ventures, multi-national companies, and contracts between companies. Analysis shows that foreign competitors, notably Japan, have based a sizeable portion of their industrial growth on borrowed technology (under licensing arrangements).

### *Civilian R&D*

Though the United States still maintains a much higher level of R&D expenditures than any individual country in the world, it is becoming evident that other countries, notably Western Germany and Japan, are placing a much higher relative emphasis on civilian R&D. In 1968, the United States spent \$13 billion for civilian R&D. Equivalent figures for Japan and West Germany amount to \$3 and \$4 billion, respectively. These individual expenditures represented 1.5% of United States GNP, versus 2.6% of German GNP and 2.0% of Japan's. If the capitalized value of purchased foreign technology is computed and added to these figures, the United States level stays the same but both German and Japanese levels jump to \$5 billion annually.

While the dollar level of our R&D exceeds the sum of West German and Japanese expenditures, there are two factors that qualify this ap-



*Computers and other high technology products are important elements in a favorable balance of trade.*

parent conclusion. One is that wage costs in those countries are much lower, with the result that they can purchase more R&D per dollar invested. Secondly, and perhaps more importantly, it takes a greater R&D effort, at much greater cost, for the leading country to find innovations to stay ahead.

### *Growing Foreign Government Incentives for New Technology*

Part of the new technological thrust of foreign competitors has been stimulated by the proliferation of investment and R&D incentives. Such incentives offered by Japan, Canada, and most of the countries in Western Europe include grants, loans, loan guarantees, interest subsidies and employment subsidies. These countries offer incentives

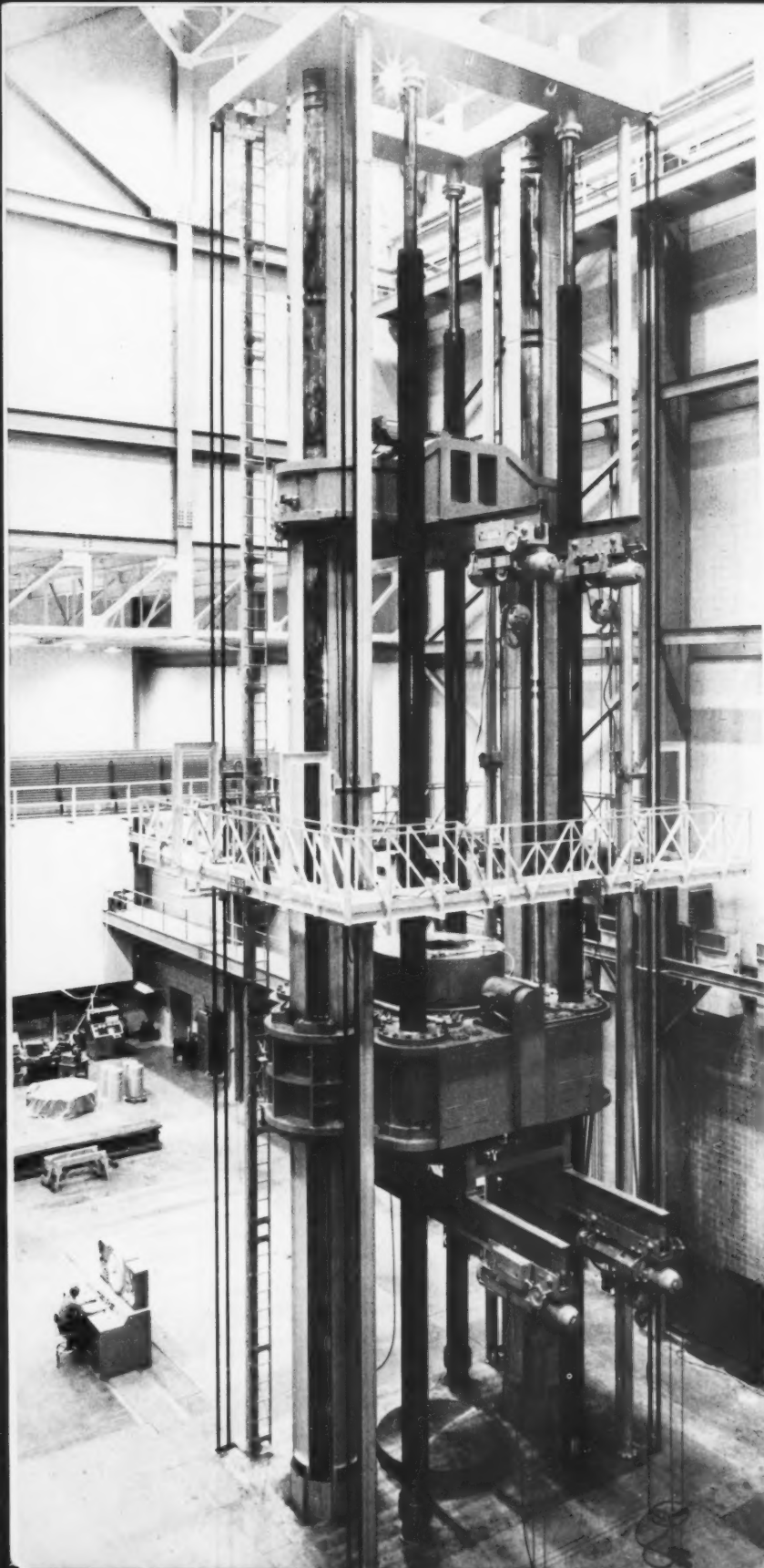
such as income tax exemptions, accelerated depreciation, and tax credits. Canada, for example, gives 25% grants for capital investment in R&D projects. West Germany provides up to a 50% write-off for R&D investment and a 10% subsidy for capital investments in R&D. Japan provides up to a 3-year tax holiday for profits on "new and important" products (in Japan the government has a very close working relationship with businesses which export).

### *Patent Activity*

There is growing evidence that other nations have been much more aggressive than the United States in patenting new technologies. Even in the applications for patents by foreigners to the U.S. Patent Office,

*Continued on p. 280*





*R. E. Snyder checks the clearance between the lugs of a 6-million lb tension testing in the testing machine. Other components for are: 11-inch threaded coupling with 6-million lbf capacity, 1 million lbf capacity, 16-inch clevis pin, tension rod assembly*

## WORLD'S LARGEST

IN AN EFFORT TO KEEP ABREAST OF THE INCREASING NEED FOR LARGE FORCE MEASUREMENTS, the Bureau has put into operation a 12-million pound capacity testing machine. The machine is believed to be the largest testing device in the world, and is capable of applying forces of 12 million pounds in compression and 6 million pounds in tension. Designed primarily for testing full-scale structural components, the machine will also be used to apply forces for calibrating large capacity force-measuring devices such as those used to measure rocket thrust.

Housed in a specially designed building, the machine has an overall height of 101 feet, 23 feet of which is below ground level. It provides 60

*Overall view of the 12-million lbf universal testing machine. The machine, believed to be the largest testing machine in the world, has just been put into operation.*

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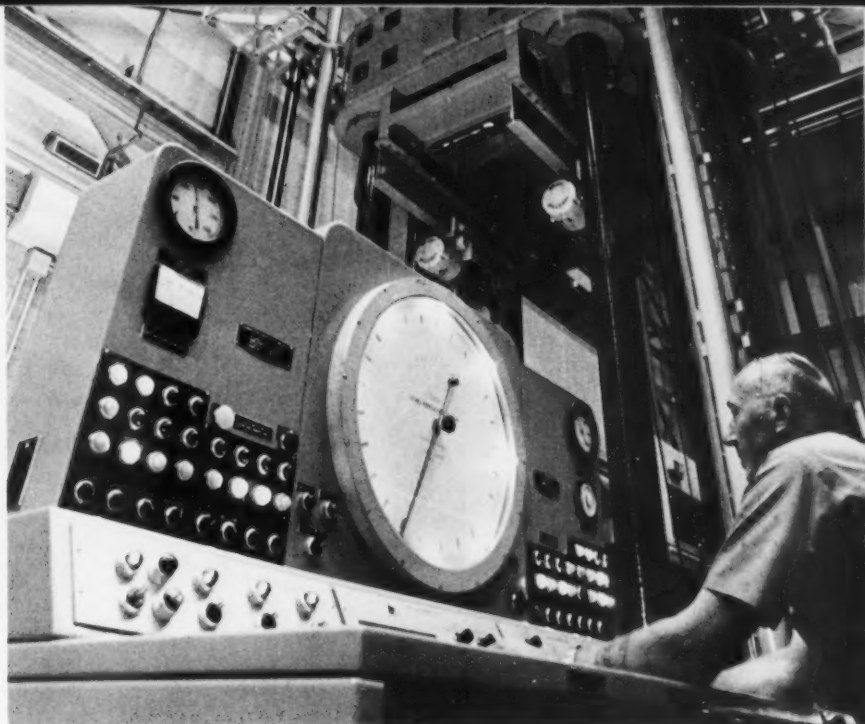
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the lugs of a 6-million lbf capacity clevis used for components for the machine, from left to right, on lbf capacity, 15-inch threaded coupling with 6-ion rod assembly, and 3-million lbf capacity



John Michalak operates the control console of the 12-million lbf capacity testing machine.

## LARGEST TESTING MACHINE GOES INTO OPERATION

feet of vertical test space for compression tests and can be used for tension tests of specimens up to 55 feet in length. In addition, structural beams up to 90 feet in length may be supported horizontally for flexure tests.

Force is generated hydraulically in the machine by a ram 6 feet 6 inches in diameter with a power stroke of 5 feet. An independent hydraulic capsule acts as the load-sensing element. Pressure from the capsule excites pressure transducers that generate electrical signals proportional to the applied load. The applied force is indicated on a control console by two independent systems, one analog and the other digital.

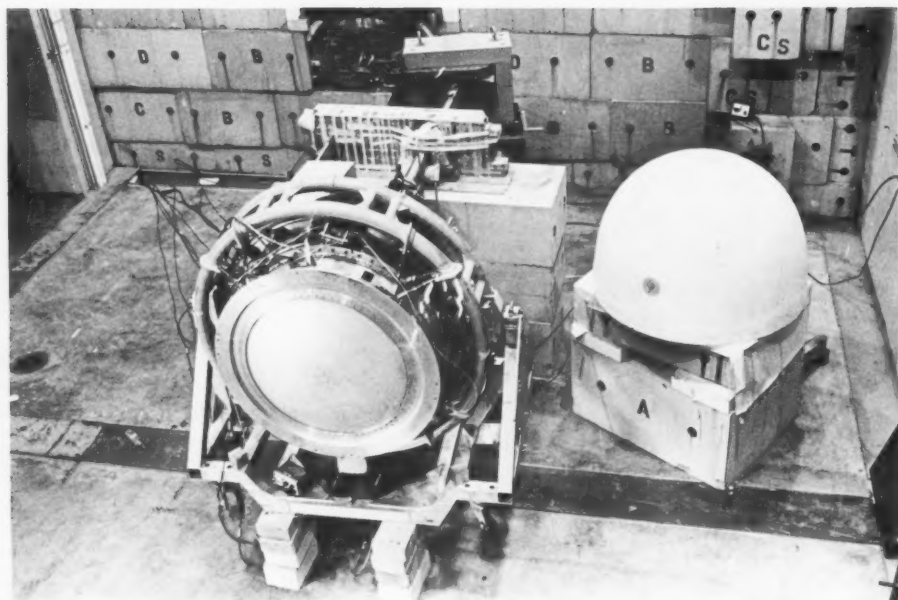
The huge size and complexity of this machine presented major problems in design, manufacture, transport, and assembly. For example, two 150-ton mobile cranes were

erected within the building to assemble components that were delivered to the site by rail and special trucks. Some of these large components then required careful hand fitting and finishing to close dimensional tolerances.

The machine will be used for testing large structural components such as those used in bridges and high-rise buildings. It will also be used in the calibration of large force transducers needed for measuring large forces for calibrating other large testing machines, for determining the pressure in rolling mills, and for other weighing and thrust measurements such as those vital to the space program. In this mode of operation a high-capacity load cell is loaded in the machine and compared with a group of smaller cells each of which has been calibrated previously by accurately known standards.

The Bureau has long recognized the need for a machine of these capabilities. It was not, however, feasible to install the device until the new facilities at Gaithersburg, Maryland, were available. The installation of this machine and several new deadweight machines with capabilities for force calibrations up to 1 million pounds has greatly enhanced the Bureau's force measurement program.

This machine was designed by Wiedemann Machine Company, a predecessor of Satec Systems, Incorporated, Grove City, Pennsylvania. Manufacture was by E. W. Bliss Company of Salem, Ohio, and the major assembly was by McDowell-Wellman Company of Cleveland, Ohio. Technical monitoring of all phases of the work was carried out by the staff of the Engineering Mechanics Section of NBS.



*A spark chamber detector, mounted in foreground, is being calibrated with known energy gamma rays from the NBS synchrotron. The detector was developed by NASA to study the gamma ray energies from strange stars. A double ring around the detector provides the suspension system for hanging from a balloon. A dome shaped hollow thermal blanket which covers the detector during flight, rests on shielding blocks at right.*

## SYNCHROTRON USED TO CALIBRATE NASA DETECTOR

THE BUREAU'S ELECTRON SYNCHROTRON was used to calibrate a spark chamber gamma-ray detector for the National Aeronautics and Space Administration. The synchrotron, unique in the Washington area, provides such high-energy, well-defined electron beams that accurate calibrations can be made using the beams.

Donald Kniffen of the NASA Goddard Space Flight Center, project scientist for the detector system, uses the detector<sup>1</sup> to identify high energy gamma rays emitted by certain celestial objects such as peculiar stars and more extended objects such as galaxies, including our own. Because gamma-ray photons are not attracted by magnetic fields, they travel in essen-

tially straight lines as do optical and radio photons. The information obtained will help scientists learn more about the major energy transfers taking place in our universe, the sources of cosmic rays, and the conditions which exist in galactic and extragalactic space.

The detector housing, resembling an astronaut's capsule, has a domed upper portion housing the spark chamber detector, and a flat underside measuring approximately 4 feet in diameter. A white styrofoam shell acts as a "thermal blanket" for the chamber dome, and a double ring frame encircling the capsule provides a suspension system support for hanging the detector from a 30 million cubic foot plastic balloon.

With the detector suspended at an altitude of about 140,000 feet, an

orientation platform points the detector in the general direction of the celestial object of interest. A wide angle aperture then allows the detector to record the arrival angle and energy of all penetrating uncharged particles (charged particles are excluded by an anticoincidence counter and all uncharged particles except the gamma rays are considered as background radiation). The data from the experiment are telemetered to a ground receiving station. The accuracy of energy and directional measurements has been carefully calibrated with the NBS synchrotron whose high gamma-ray energies are comparable to those expected from the gamma rays of the stars.

<sup>1</sup> Kniffen, D. A., and Fichtel, C. E., A study of gamma rays from the region of the galactic center, *Astrophys. J.* **161**, L157 (Sept. 1970).

# POSTDOCTORAL RESEARCH ASSOCIATESHIPS FOR 1972

The Bureau's 1972 Postdoctoral Research Associate Program is now underway, and brochures describing the program are available. For 18 years, NBS has been actively engaged in the cooperative program with the National Research Council, National Academy of Sciences-National Academy of Engineering to offer young men and women with recent doctoral degrees, or their equivalent, an opportunity for researching many areas of deep concern to the scientific and technological community of the Nation. NBS engages in research covering many of the physical and social sciences at two major facilities: Gaithersburg, Maryland, and Boulder, Colorado. Postdoctoral applicants will be competing for positions in the physical sciences including physics, chemistry, radiation research, mathematics,

metrology, and Standard Reference Materials, and in areas of social relevance, including research in building technology, electronic technology, fire technology, product performance and safety, and systems analysis.

A limited number of applicants are selected initially for 1 year to work closely with a senior member of the scientific staff on a problem of mutual concern. Extension of an Associateship may be granted after 6 months tenure if such an extension would appear to benefit both the Associate and NBS. An applicant is responsible for the selection of a research program of his own interest and ability related to one of the approximately 350 available research programs, for the formulation of the research plan, and for obtaining the approval of one of the scientific advisers

listed in the brochure. He must then submit his application and all supporting documents to the Associateship Office of the National Research Council *not later than January 15, 1972*. The brochure and general information regarding the Postdoctoral Research Associateship program at NBS may be obtained from Dr. Shirleigh Silverman, Administration Building A1111, National Bureau of Standards, Washington, D.C. 20234. (telephone (301) 921-2461).

To qualify for the Postdoctoral Research Associateship an applicant must be a citizen of the United States, and have received his Ph.D. or equivalent degree not earlier than 2 years prior to submitting his application. Applicants are expected to have demonstrated superior ability for creative research.

## ATOMIC WEIGHTS *Continued*

permits a straightforward calculation of the atomic weight of zinc. Absolute current and time measurements were employed in this work.

Preliminary research showed that the presence of oxygen in the electrolyte had a significant effect on the rate of spontaneous corrosion of zinc. For this reason, a nitrogen atmosphere was maintained in the coulometer throughout experimentation. It was also observed that commercial grade zincs yield a higher electrochemical equivalent than the same materials subjected to vacuum fusion. Initial experiments showed that zinc anodes amalgamated on the surface undergo electrochemical dissolution without the fall-off of material demonstrated by pure zinc electrodes during electrolysis. The cur-

rent efficiency for the anodic reaction was 100 percent for the current densities used.

The coulometer used in this research was made up of a weighed zinc amalgam anode suspended above a mercury pool cathode. A porous membrane filter inserted under the amalgamated anode showed no fall-off during the electrochemical dissolution. A constant current of known magnitude was passed through the electrochemical cell for a precalculated period of time sufficient to produce a change in mass of the anode roughly equivalent to two grams. Depending on the current used in a particular experiment, the time period involved ranged from  $3$  to  $7 \times 10^4$  seconds.

The studies, based on five metallic reference samples, revealed no significant difference among the

values of atomic weight for refined materials of different origins. However, to insure that the value obtained in this research is truly representative of terrestrial zinc, an experimental survey of primary zinc-bearing minerals from worldwide sources is now in progress. The value given here ( $65.377 \pm 0.003$ ) is based on preliminary results but other available data are in excellent agreement with these figures. With the completion of the data processing, a further reduction in the uncertainty of this constant is anticipated. Although the method is not applicable to all elements, coulometric measurements of the atomic weights of other electrochemically active elements are being attempted.

<sup>1</sup> Marinenko, G. and Foley, R. T., A new determination of the atomic weight of zinc, *J. Res. Nat. Bur. Stand. (U.S.)*, **75A**, No. 6 (Nov.-Dec. 1971).



# SITING AIR POLLUTION SAMPLERS

## NBS ASSISTS ENVIRONMENTAL PROTECTION AGENCY

AIR POLLUTANTS MUST BE MEASURED BEFORE THEY CAN BE CONTROLLED. Now that pollutants are being measured systematically in metropolitan areas, choosing locations for air pollution samplers becomes important. For this reason Bureau operations research analysts were asked to formulate site selection procedures for the Division of Air Quality and Emission Data, National Air Pollution Control Administration (NAPCA)\*. The procedures were needed especially because of an anticipated large increase in monitoring stations due to legislation then in process. The work was performed at NBS by Alexander Craw, with the assistance of NBS and NAPCA personnel. They demonstrated the procedures by using emission, population, and meteorological data for an actual Air Quality Control Region (AQCR) as inputs to a computer-operated diffusion model.

### SELECTING SAMPLER SITES

How do you choose locations for air samplers so that the data are of the most possible use? Should the sites be on a regular grid or randomly arranged? Should they be closer together near sources of pollution? How should they be sited in order to be most representative of a given area? There was no need to ask these questions when, in 1953, the Public Health Service established an air sampling network that relied on voluntary efforts to operate 17 samplers in 17 communities. This system, the National Air

Sampling Network (NASN), was revised in 1957 and 1961 and enlarged to include about 250 cities. Not until 1967 did NASN receive data from multiple sites in communities, making it necessary to concern itself with local patterns of air pollution.

At first the NASN sampled only particulate matter—solid particles and liquid droplets—but it now can monitor gaseous materials, also. The air samples are analyzed for sulfates, nitrates, soluble particles, and for many metals. The Federal Government supplies sampling equipment to the cooperating local governments, which agree to operate the equipment on a schedule prescribed by NAPCA—a 24-hour period for a day selected during each 2-week period. NAPCA also made recommendations regarding the sites at which the equipment was to be installed.

### NBS APPROACH

For most cities no pollutant distribution data are available for use in selecting sampler sites. In such cases NBS projected pollution concentration patterns as the output of a computer-operated atmospheric diffusion model for the city or locality. An existing NAPCA program was modified for this project to enable the model to be run on the Bureau's UNIVAC 1108 computer. The model—fed as input existing emission data, meteorological data (wind direction and speed and atmospheric stability class data for the specified season), and population data—shows concentrations of

the geographical spread of each pollutant. If any actual concentration data exist, the model scales can be adjusted to coincide with the known values.

From the calculated data, projected concentration contours can be plotted on maps for each pollutant or combination of them for specific seasons. A band can also be identified that contains pollution concentrations within a given amount of the mean value (or other chosen value) over the area of interest. These contour maps for each pollutant and season of interest are then superimposed, and sampler location points are selected at which the bands overlap or intersect. Sites can be selected in this way to satisfy multiple objectives; since sampling equipment is limited, such points are the preferred sampler locations for the pollutants and seasons of interest.

### THE BUFFALO EXPERIMENT

The NBS site location procedure was applied experimentally to the Buffalo (New York) AQCR, consisting of Niagara and Erie counties. For modeling purposes each 5 km × 5 km square was considered to be an area source and 21 specific elevated sources were considered to be point sources. Emission data for this region were obtained from NAPCA and meteorological data for a year were obtained from the National Weather Records Center for input to the computer model. Only gaseous sulfur oxides (SO<sub>2</sub> and SO<sub>3</sub>) and particulate emissions were considered.

The model has a feature based on the concept that it is not the pollution itself that is of interest, but the effects of the pollution, which depend partly on population densities. The diffusion model program used for this project accepted five different weighting factors for the population densities. The weighting factors "plugged in" were, in addi-



tion to unity, those representing the 1969 residential population, the 1969 work (daytime only) population, the projected 1975 residents, and the projected 1985 residents.

The outputs of the computer-

operated diffusion-population models were printed out on a large plotter, giving concentrations of the sulfur oxides and particulates for summer and winter months. These predicted contours were studied to

find locations that would measure maximums of both pollutants as well as locations where area average values could be sampled.

\*Now the Division of Atmospheric Surveillance, Environmental Protection Agency.



## STANDARD FREQUENCY AND TIME BROADCASTS

High-frequency radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast time signals on the Coordinated Universal Time (UTC) system as coordinated by the Bureau International de l'Heure (BIH), Paris, France. The NBS time scale, UTC(NBS), and the U.S. Naval Observatory time scale, UTC(USNO), are jointly coordinated to within  $\pm 5$  microseconds. The UTC pulses occur at intervals that are longer than one coordinated second by 300 parts in  $10^{10}$  during 1971, due to an offset in carrier frequency coordinated by BIH. To maintain the UTC scales in close agreement with the astronomers' time, UT2, phase adjustments are made at 0000 hours Greenwich Mean Time (GMT) on the first day of a month as announced by BIH. *There will be no adjustment made on December 1, 1971.*

The low-frequency radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses without offset to make available to users the standard of frequency so that absolute frequency comparisons may be made directly, following the Stepped Atomic Time (SAT) system. Step time adjustments of 200 ms are made at 0000 hours GMT on the first day of a month

when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be no adjustment made on December 1, 1971.*

NBS obtains daily UT2 information from forecasts of extrapolated UT2 clock readings provided by the U.S. Naval Observatory with whom NBS maintains close cooperation.

## BROADCAST OF NEW TIME SCALE

Since 1967 the second has been defined in terms of an atomic transition, while time scales in general use are based on the rotation of the earth. This has resulted in the dissemination of a compromise time scale arrived at by international agreement through the International Radio Consultative Committee, and maintained by the International Bureau of Time (BIH). This scale, known as Coordinated Universal Time (UTC), presently operates with a frequency offset from the atomic scale of  $-300 \times 10^{-10}$  to approximately agree with the rotation of the earth. Occasional step adjustments in time of 0.1 second are also made to compensate for unpredictable variations in the earth's rate of rotation.

To avoid the disadvantages of having an offset frequency and fractional second step adjustments, the UTC time scale will change on 1 January 1972. The new UTC scale

will operate with no frequency offset, thus providing time intervals that are exactly one second long. The scale will continue to keep in approximate agreement with earth time, known as UT1, by step adjustments of exactly one second occurring about once per year. There will be a preference of adjustments on the 1st of January and July. In any case the new UTC scale should not differ from UT1 by more than 0.7 second.

In the U.S., therefore, the NBS standard broadcast services of WWV, WWVH, and WWVL will be changed to have zero offsets in their carrier and modulation frequencies and time signals. At 00 hours on 1 January 1972, UTC will be reset a fraction of a second, sufficient to give the new UTC scale an initial difference of an integral number of seconds (probably 10,000 seconds late) with respect to International Atomic Time (IAT) as maintained by the BIH. UTC is now about 9 seconds late compared to IAT, and during the next year the difference will probably increase to about 10 seconds; thus, the reset should be only a few hundred milliseconds. Thereafter, the difference between UTC and IAT will always be an integral number of seconds. The difference between UT1 (not UT2) and the broadcast signal will also be given after 1 January 1972, probably with a resolution of 0.1 second.

## ECONOMY *Continued*

the share of foreign applications for United States patents has grown steadily from 25% of United States patent applications in 1961 to nearly 45% in 1969. This, of course, represents only a portion of the total foreign patent activity.

**Fixed Assets.** In terms of annual growth and percent of GNP, United States competitors are out-performing the United States in the rate of investments in fixed assets for durable equipment and nonresidential structures for business purposes. This has been true since 1950 and more pronounced since 1959. From 1959-69, the United States annual growth rate in investment in fixed assets was 5.8% compared with 9.2% for France, 6.1% for West Germany and 16.9% for Japan. In terms of relative effort our competitors again outdo the United States. In 1969, United States share of GNP devoted to investment in fixed assets was less than 11%; comparable levels for France, Germany and Japan were 18%, 19% and 29% respectively.

**Labor Cost Considerations.** The maintenance of technological advantages, while vital for national security, is also essential for the Nation's economic well-being. Given our higher labor costs, it is only in the product areas with technological superiority where we can expect to maintain our economic competitiveness. In the absence of compensating technological factors which result in a better quality of product, unique products, or cheaper production methods, the United States is faced with a critical cost disadvantage due to its high labor costs. Though labor costs have been rising rapidly in competitive countries, the differential is still vast. In 1970, Japanese labor costs (including fringe benefits) were only 26% of the United States levels, United Kingdom levels were 37%, France 39%, West Germany 54% and

Canada 83%. While such differences may narrow somewhat in the foreseeable future it is not likely that wages in these countries will match those in the United States for a long time. The spread of course is even greater in the case of the developing countries.

## WHY SHOULD THE FEDERAL GOVERNMENT BE CONCERNED?

The situation I have just described is clearly serious and growing worse. It has already affected our international trade position and promises to have an even greater impact in the future.

The magnitude of the problem is such that we cannot rely upon normal market forces to maintain our advantage in technology. We are at the forefront in many technological areas. The costs of breaking new ground in some of these areas are higher—higher than private companies or perhaps even private consortia are able to justify because the risks are so great. We have recognized this fact in the space, defense, and atomic energy areas. Other trading nations have recognized it in the area of civilian R&D and have taken steps to assist technological development. If we are to maintain our advantages in this area we must first of all accept the idea that it has become a proper sphere for governmental action.

## OBJECTIVES

Our objectives in technology are readily described. We must strive to:

- Remove barriers impeding the use of existing technology.
- Stimulate better use of existing technology.
- Remove barriers impeding the development and use of new technology.
- Stimulate the development and use of new technology.

Let me now turn to some of the ways we might proceed to attain

these objectives. These alternatives are presented in the nature of program options each of which will require extensive further analysis in order to determine if, in fact, it provides an effective and acceptable way of maintaining our technology lead.

## Program Option 1

We should examine the feasibility of establishing a single federal focus for several activities directly related to enhancement, assessment and forecasting of industrial technology. These activities would include:

- Identification of technology opportunities in various industries.
- Assessment of current technological strengths and weakness.
- Forecast of future technological developments.
- Development of specific industrial technology enhancement programs.
- Establishment of mechanisms to guide technology transfer.
- Development of educational and training programs designed to encourage invention and innovation.
- Acceleration of domestic dissemination of the results of government sponsored R&D.

Some of the above activities are not now being performed. Others are scattered throughout the government and thus lack the consistent and coherent thrust that is required to obtain effective results. We should set about determining which of these activities are required and where they would best be located.

## Program Option 2

Because of the increasingly high costs and risks of exploration on the technological frontier, we should carefully explore the feasibility of creating direct and indirect financial incentives aimed at stimulating the development and utilization of

new technology. Several alternatives are available. For example, should direct federal assistance be provided through:

- loan guarantees?
- cost sharing?
- grants?
- procurement incentives?

Indirect financial assistance could take the form of tax incentives for R&D and capital expenditures. Perhaps the United States will need to match some of the tax incentives (depreciation allowances, investment credits, credits for incremental R&D, favorable treatment for casual inventors) offered by its competitors.

#### Program Option 3

Substantial progress might also be made simply by freeing our industries from some of the burdens under which they, but not their foreign competitors, operate. The high costs and risks of technological development, for example, might well be spread among a number of firms, but our antitrust rules now prevent this by prohibiting joint ventures and joint research.

It may well be time to modernize antitrust laws which evolved to deal

with the different problems of an earlier era in order to permit the pooling of funds and risks that must accompany major technological advances.

#### Program Option 4

Technological development and utilization is frequently delayed by the lack of generally accepted industrial standards. Potential manufacturers hesitate to invest heavily in the introduction of innovative equipment when they are uncertain about the requirements or specifications which will define the market for such equipment, especially in export trade. We should encourage the setting of voluntary standards where appropriate and mandatory ones where absolutely necessary.

But today voluntary standards making is usually inhibited by antitrust laws. Again, it may be time to reexamine these laws to ensure that they meet the needs of today. More effective standards can also be achieved by:

- avoiding frequent changes in standards
- substituting performance standards for material standards
- preempting state and local

standards or promoting uniformity among them.

In international trade, it is extremely important that the United States insist upon participating in standards-setting negotiations to avoid prejudice to our products. Legislation to this effect is now before the Congress.

#### CONCLUSIONS

I do not presume, today, to suggest which of these options are most effective or even most desirable. A considerable amount of thorough analysis by both the Executive and Legislative Branches is necessary in order to settle upon that combination which will maintain the preeminence of American technology in the world market.

This work is now proceeding in the Department of Commerce and other units of the Administration. My sole objective in testifying today has been to point up the significant relationship between technology and commerce, especially its significance to our international economic strength.

If we recognize the importance of this relationship, I am confident that we can find the correct solution.

## Conference on Accuracy in Spectrophotometry and Luminescence Measurements

A conference on Accuracy in Spectrophotometry and Luminescence Measurements will be held at NBS on March 22-24, 1972. The purpose of the conference is to focus attention on both the physical and chemical problems related to accurate spectrophotometric, fluorometric and phosphometric measurements of materials. The status of these competences from the standpoint of basic principles

and instrumental parameters will be defined. A critical survey of analytical needs will emphasize measurement problems in the areas of health and environment.

Sponsored by the NBS Analytical Chemistry Division, the conference will feature eighteen internationally known speakers and panelists. The topics to be presented include discussions of basic principles, instrumental parameters, criteria for

standards and specific needs. It is hoped that the results of this conference will provide stimulus for the accurate measurement of properties of a variety of materials based on their transmittance and emission characteristics.

For further information contact Dr. Oscar Menis, General Chairman, B-224 Chemistry Building, National Bureau of Standards, Washington, D.C. 20234.

# Precision Measurement Grants

The Bureau has presented its 1971 Precision Measurement Grants to Professor Norval Fortson, Physics Department, University of Washington; Professor William Parker, Physics Department, University of California, Irvine; and Professor Arthur Rich, Physics Department, University of Michigan. The grants were made in recognition of their outstanding work in measurement science, work that provides the quantitative basis needed for much of our science and technology today. Grants of \$15,000 each are awarded each year to scientists whose research reveals unusual talent for developing improved precision measurement techniques.

Professor Fortson has developed techniques for making high precision measurements on stored ions and for studying ion-atom collision processes. Ions are trapped in a high vacuum by suitable electric and magnetic fields. The long storage times achieved minimize perturbations and enhance the accuracy of the results which can be

obtained. Professor Fortson also worked earlier on the development of the hydrogen maser.

Professor Parker's research has been concerned with the precise measurement of fundamental constants using the phenomenon of flux quantization in superconductors at low temperatures. With associates at the University of Pennsylvania, he carried out a very accurate measurement of the ratio of the electron charge to Planck's constant. He is now engaged in a new experiment to determine the ratio of Planck's constant to the electron mass.

Professor Rich has developed a new technique for measuring the cyclotron frequency of ions to high precision. The results are expected to improve our knowledge of the proton mass, the faraday, and Avogadro's number. Professor Rich was earlier involved in measurements of the difference between the spin precession and cyclotron resonance frequencies of positrons and electrons in a known magnetic field.

NBS makes three new grants

each year, and extends a number of them for periods of up to three years. The grants are not intended to replace other sources of support but to assist research workers in technically advancing their new ideas and novel techniques of precision measurement to a point where they can obtain other funds. Recommendations for the grants are made by scientists who have made major contributions to precision measurement. The committee for this year consisted of: Professor H. G. Dehmelt, University of Washington; Professor W. Fairbank, Stanford University; Professor V. W. Hughes, Yale University; Professor N. Ramsey, Harvard University; and Professor J. Weber, University of Maryland.

NBS welcomes suggestions concerning potential grant recipients. Suggestions should be received by January 1, 1972, to be included in the next fiscal year's program, and should include a list of the nominee's publications and some information on the research area in which he is now working. Preference will be given to younger scientists in awarding the grants. All suggestions and comments should be addressed to Dr. Shirleigh Silverman, Office of Academic Liaison, Administration Building A-1111, National Bureau of Standards, Washington, D.C. 20234.

## VAPOR PRESSURE *Continued*

ments, it is desirable to have a formulation that is in closer agreement, preferably within the estimated uncertainty of the vapor pressure measurements.

In the NBS work, the Clausius-Clapeyron equation was integrated using the accurate calorimetric data of Osborne, Stimson, and Ginnings along with the Goff and Gratch formulations for the virial coefficients of water vapor.<sup>3,4</sup> The equation was then adjusted to bring it into closer accord with the pressure measurements.

The derived equation is as follows:

$$\ln p = \sum_{i=0}^5 E_i T_i^{-1} + B \ln T_{48}$$

where  $T$  is in Kelvin ( $IPTS_{48}$ ),  $E_0 = -7.51152 \times 10^3$ ,  $E_1 = 9.65389644 \times 10^1$ ,  $E_2 = 2.3998970 \times 10^{-2}$ ,  $E_3 = -1.1654551 \times 10^{-5}$ ,  $E_4 = -1.2810336 \times 10^{-8}$ ,  $E_5 = 2.0998405 \times 10^{-11}$ , and  $B = -1.2150799 \times 10^1$ . A similar equation with eleven terms was derived for the  $IPTS_{68}$  temperature scale.

Using the equation two tables of vapor pressure were generated,

one based on  $IPTS_{68}$  and the other on  $IPTS_{48}$ . The tables are expressed in pascals as a function of temperature at 0.1 degree intervals over the range 0 to 100°C.

<sup>1</sup>Wexler, A., and Greenspan, L., Vapor pressure equation for water in the range 0 to 100°C, J. Res. Nat. Bur. Stand. (U.S.), **75A** (3), 213-229 (May-June 1971).

<sup>2</sup>Stimson, H. F., Some precise measurements of the vapor pressure of water in the range from 25 to 100°C, J. Res. Nat. Bur. Stand. (U.S.), **73A** (4), 493-496 (Sept.-Oct. 1969).

<sup>3</sup>Flück, E. F., and Ginnings, D. C., Heat of vaporization of water at 50°, 70°, and 90°C, J. Res. Nat. Bur. Stand. (U.S.), **68**, 321-324 (1932) RP416.

<sup>4</sup>Goff, J. A., Standardization of thermodynamic properties of moist air—final report of the Working Subcommittee, International Joint Committee on Psychrometric Data, ASHVE J. Section, Heating, Piping and Air Conditioning 55, 118 (1949).



# The First Evidence of Promethium in a Star

SPECTRAL DATA PROVIDED BY THE BUREAU have led to the first positive identification of promethium in a star. Promethium, a short-lived element which has no stable isotopes, has been identified spectroscopically in the A type star HR 465 by Margo F. Aller and Charles Cowley of the University of Michigan.<sup>1,2</sup> Identification of promethium was obtained by comparing the observed spectra first with the early (1951) NBS spectral data of William Meggers, Bourdon Scribner, and William Bozman,<sup>3</sup> and then with more recent spectral data of Joseph Reader of NBS, who had collaborated in this work with Sumner Davis of the University of California, Berkeley.<sup>4</sup> Unpublished data on the sensitive lines of other elements was provided by Charles Corliss, also of NBS.

The discovery of promethium in stars is important in two ways: It demonstrates that promethium is naturally present in the universe. And as it is a short-lived, unstable

element, it must be produced near the surface of a star, otherwise its natural transport to the surface from deep within the star's interior would surpass the lifetime of the element. The identification has thus raised questions of great importance for understanding stellar evolution.

Spectral data of HR 465, obtained in 1961 by William P. Bidelman with the Lick 120-inch telescope, showed an unusually large number of spectral lines. He successfully identified 75 percent of the lines, revealing that the star was unusually rich in the rare-earth elements. Aller and Cowley began their identification of promethium by comparing the line list from Bidelman's spectrograms with wavelength and intensity measurements on promethium provided by Meggers, Scribner, and Bozman of NBS.<sup>3</sup> All eleven of the strongest promethium (Pm II) lines were present in the HR 465 spectra.

As a check, Aller and Cowley examined seven of the strongest stel-

lar lines that they assigned to promethium, to determine if the lines could have been produced by other elements. With catalogued spectra and data provided by Charles Corliss of NBS, Aller and Cowley concluded that the seven stellar lines could only be attributed to promethium.

A further conclusive check of the presence of promethium was the identification of the resonance lines of the element, produced when a ground state electron jumps to the first excited state. With the data of Reader and Davis, the Michigan team was able to verify that promethium resonance lines were present.

<sup>1</sup> Aller, M. F., Promethium in the star HR 465, *Sky and Telescope*, 220 (Apr. 1971).

<sup>2</sup> Aller, M. F., and Cowley, C. R., The possible identification of promethium in HR 465, *Astrophys. J.* **162**, L145 (1970).

<sup>3</sup> Meggers, W. F., Scribner, B. F., and Bozman, W. R., Absorption and emission spectra of promethium, *J. Res. Nat. Bur. Stand. (U.S.)*, **46**, 85 (1951).

<sup>4</sup> Reader, J., and Davis, S.P., Fundamental energy levels of neutral promethium (Pm II), *J. Res. Nat. Bur. Stand. (U.S.)*, **71A**, 587 (1967), and unpublished data on singly-ionized promethium.

## ACCELEROMETERS *Continued*

with the acceleration value desired. If the correct value has not been obtained, the computer determines and places in the data block a new value for oscillator voltage, which it retains for use in determining subsequent excitation voltages. When the measured acceleration level is within an established tolerance of that desired, the computer reads the voltage ratio of the test accelerometer output to the reference accelerometer output. The computer calculates the test pickup's calibration factor, prints it on the typewriter, records it in the memory for later plotting, and proceeds to the next set of calibration parameters.

## SYSTEM FEATURES

Several advantages are brought to the calibration system by the programmable oscillator used. It supplies digitally set frequencies having high accuracy and a low harmonic distortion (less than 0.05%). Most important, the computer maintains each output until the calibration parameters have reached a steady state and only then measures the pickup's sensitivity.

Changes in the test sequence can be made by keyboarding the instructions to the computer to override the initial program. The operator can at any time, for example, rerun a test in order to determine the repeatability of the measurements.

The test pickup frequency response plot can be given an increasingly analog character by decreasing the size of the frequency increments, thereby increasing the number of data points.

If different circuit components or computer accessories are to be used, they can be inserted in the configuration at a quick-connect panel. It is useful, also, in calibrating the ac-to-dc voltage converters, inspecting the purity of the excitation waveform, and various other measurement tasks.

<sup>1</sup> Payne, B. F., An automated precision calibration system for accelerometers, *Proc. of 17th Nat. Aerospace Instr. Symp. of the Instr. Soc. Am.* (May 1971).

<sup>2</sup> Frequency range of calibration vibrators extended; ceramic armature and air bearings improve performance, *Nat. Bur. Stand. (U.S.)*, *Tech. News Bull.* **51**, 90-92 (May 1967).





# NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

## SELECTED TABLES OF ATOMIC SPECTRA

The latest critical compilation in the NSRDS series is Section 4 of NSRDS-NBS 3, *Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables N IV, N V, N VI, N VII* by Charlotte E. Moore<sup>1</sup> (55 cents, SD Catalog No. C13.48:3/Sec. 4). This publication is part of a series being prepared in response to the increasing demand for a current revision of two sets of tables containing data on atomic spectra as derived from analyses of optical spectra. Meanwhile, work is underway to update and revise the first set, *Atomic Energy Levels*, NBS Circular 467, which will be reprinted and published at a later date as NSRDS-NBS 35, Volumes I, II, and III.

The second set consists of two Multiplet Tables; one published in 1945 by the Princeton University Observatory contains multiplets having wavelengths longer than 3000 Å; the other, *An Ultra-Violet Multiplet Table*, NBS Circular 488, was issued in five Sections, the first in 1950, the second in 1952, and the others in 1962. The 1945 Princeton

Multiplet Table is being updated and reprinted as NSRDS-NBS 40.

The present NSRDS-NBS 3 series includes both sets of data, the energy levels and multiplet tables as parts A and B, respectively, for selected spectra contained in Volume I of "Atomic Energy Levels." The Sections are being published at irregular intervals as revised analyses become available. A flexible paging system permits the arrangement of the various Sections by atomic number, regardless of the order in which the separate spectra are published. NSRDS-NBS 3, Section 1<sup>1</sup> (35 cents, SD Catalog No. C13.48:3/Sec. 1) includes three spectra of silicon, Z=14: Si II, Si III, Si IV. Section 2<sup>1</sup> (20 cents, SD Catalog No. C13.48:3/Sec. 2) contains similar data for Si I. Section 3<sup>1</sup> (\$1, SD Catalog No. C13.48:3/Sec. 3) covers all the spectra of carbon, Z=6. C I, C II, C III, C IV, C V, C VI. Section 4 includes four spectra of nitrogen, N IV, N V, N VI, N VII. Section 5 is scheduled to include the remaining spectra of nitrogen: N I, N II, N III. The form of presentation of the data is described in detail in the text of Section 1.

## JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA

Beginning in 1972, the major portion of the output of the National Standard Reference Data System will be presented in a quarterly journal jointly published by the American Institute of Physics (AIP), the

American Chemical Society (ACS) and the National Bureau of Standards. Entitled *Journal of Physical and Chemical Reference Data*, the periodical will carry the compilations and reviews of evaluated reference data produced by the National Standard Reference Data System heretofore published through the United States Government Printing Office and sold by the Superintendent of Documents.

The following subscription rates for the Journal have been established: Domestic Members of AIP and ACS, \$20; Foreign Members of AIP and ACS, \$23; Nonmembers, Domestic, \$60; and Nonmembers, Foreign, \$63. All subscriptions should be sent to the American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036. AIP members should identify the member or affiliated society in which they hold membership.

## CODATA PANEL DISCUSSION ON STATE OF TRANSPORT DATA

The following material is excerpted from a report by Y. S. Touloukian, Director of the Thermophysical Properties Research Center and Chairman of the CODATA Panel on Transport Properties Data, presented at the September 1970 meeting of the International Council of Scientific Unions Committee on Data for Science and

Technology (CODATA) at St. Andrews, Scotland. Although Dr. Touloukian's report was on transport properties, much of the matter is applicable to data evaluation in general.

"Transport (or nonequilibrium) properties are considered distinctly separate from thermodynamic (or equilibrium) properties to the extent that they differ in the fundamental treatment of the integral differential equations describing them. Because of both the theoretical and experimental difficulties in the prediction and measurement of these properties, I believe one can state that our knowledge of these important properties is one order of magnitude less than equilibrium thermodynamic properties . . .

"Before embarking on the summary of the deliberations of the panels yesterday afternoon, I wish to take this opportunity to define carefully the usage of certain terms. In the sense used in these deliberations, the term "Critical Analysis" implies that a body of data has been critically reviewed and evaluated by individual experts in the field, having a significant degree of sophistication. As a result of such close scrutiny of the data, one normally arrives at a set of recommended values which are considered as the "most probable" value of the property at a given time; reserving the privilege of changing the recommendations at a future date based on newer data and/or improved state of knowledge. While "critical analysis" always does set a level of confidence for the recommended values, there is *no* implication whatsoever of high accuracy or precision of the recommended values.

"In the field of transport properties data we have no illusion that we can find the answers to problems with the use of the almighty computer. While at best the computer gives us a hope for possible solutions to a number of these problems, it cannot eliminate the

requirements of the "man-machine" interfacing. Note that the important part in this term is the *man* and not the *machine*. For the future, the answer to knowing what it is that we know rests in the further development of specialized information analysis centers (IAC) of excellence to perform the functions of the synthesis of knowledge. Therefore, the specialized IAC is a technical institute and not a mechanized technical library. I wish to conceive therefore that at its best the specialized IAC interposes itself as a filter between the flood of diffused information of high noise level and the ultimate user of this information, the engineer and scientist. The effectiveness of such a center is measured, therefore, by its ability to increase the signal-to-noise-ratio in the published information, as well as the range of the band-width of the spectrum it covers. Data synthesis truly creates new knowledge feeding itself on the fragments of conflicting knowledge, thus making contributions of original information of lower level of entropy than what is commonly reported to be *original research*. The thermodynamic explanation, of course, is found in the negative entropy provided by the synthesizer or analyst.

"A panel discussion was organized for Wednesday afternoon, September 9, to deliberate on the state of numerical data on transport properties of materials (excluding biological substances). Twenty-four attended the discussions and of those present at least fifteen participated actively. Considering the fact that the Second CODATA Conference did not primarily represent specialists in the transport properties area such an attendance serves as an indication of the interest in and importance of the topic. While a tentative agenda was prepared for the discussion it was not possible to cover all subject areas. For effectiveness of the discussions, those

present conducted their deliberations in two separate groups; namely, on fluids and solids, under the leadership of D. T. Jamieson and R. Berman, respectively, with J. R. Sutton and R. E. Taylor serving as recording secretaries. The major points discussed were as follows:

"State of the theory, its adequacy, and the need for selective new data of high accuracy for further advances.

"The dire need of well-characterized standard reference materials whose properties are well-established. (In this connection, I would point out that the International Union of Pure and Applied Chemistry (IUPAC)\* recommends only five organic liquids as standards for thermal conductivity only over 45 °C temperature range in the extreme case. The one-half per cent accuracy assignment is also contested.)

"In the case of liquids, the problem of thermal radiation exchange was discussed at some length primarily relative to recent results communicated by Dr. Poltz from the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Federal Republic of Germany. These results, while still debatable, cast doubt on the suitability of toluene as a reference liquid.

"The possibility of selecting fluids for secondary industrial standards was also mentioned. It was recognized that while all these considerations did directly influence the analysis of data, they would be outside the prime charter of CODATA as presently interpreted and, therefore, these discussions were not elaborated.

"The urgent need for the determination of the causes for the excessive discord in data was stressed. It was felt that a critical examination and assessment of the major techniques in current use is urgently needed, as they are cluttering the literature with new results

which further confuse the picture. While it was strongly felt that the analysis of techniques is very much in the domain of the IAC's, the discussion was not pursued to any greater length because the subject once again was considered to be somewhat outside the domain of CODATA as presently conceived. A means must be found within CODATA to accommodate discussion on and full consideration of experimental techniques which are so closely related to the data of science and technology.

"Special peculiarities to be resolved in both fluids and solids were brought up and stressed. For the case of nonmetallic solids the necessity of specimen size and geometry specification with the test results (in addition to other characterization parameters) was pointed out as necessary for low temperatures even as high as 100 to 150 K.

"In the case of liquid metals, if recent results on thermal conductivity are confirmed, it will require a modification in the present theory.

"The degree of adequacy of the data on the viscosity and thermal conductivity of water substance was briefly discussed.

"Towards the end of the discussion, those present felt the need for pursuing further, and on a continuing basis, exploration of those aspects of the discussion which clearly fall within the domain of CODATA. A resolution to establish a CODATA Task Group on Transport Properties will therefore be

submitted formally to the CODATA Bureau no later than January 1971."

#### ORDERING INFORMATION FOR THIRD EDITION, CRYSTAL DATA, DETERMINATIVE TABLES

Recognizing the need for updated crystallographic information, the Office of Standard Reference Data has sponsored the issuance of the Third Edition of Crystal Data, Determinative Tables. The publication should be of particular interest not only to crystallographers but also to chemists, mineralogists, physicists and individuals in related fields of study. The current edition, which comprises two volumes, Organic and Inorganic, is a thoroughly revised and updated work, containing over 30,000 entries.

The entries are listed, within each crystal system, according to increasing values of a determinative number:  $a/b$  ratio in trimetric systems,  $c/a$  ratio in dimetric systems, and cubic cell edge  $a$ , in the isometric system. In addition, the following information is given: axial ratio(s) and interaxial angles not fixed by symmetry, cell dimensions, space group or diffraction aspect, number of formula units per unit cell, crystal structure (whether determined), measured density and x-ray calculated density. Also listed is the name of the compound and synonym(s), chemical formula, literature reference and transformation matrix. When available, the crystal structure type, crystal habit, cleavages, twinning, color, optical

properties, indices of refraction, optical orientation, melting point and transition point are also listed.

The first edition of *Crystal Data* was published as Memoir 60 of the Geological Society of America in 1954. The second edition was issued in 1967 as Monographs 5 and 6 of the American Crystallographic Association. Both editions proved extremely valuable to crystallographers throughout the world. The present edition culminates years of effort by J. D. H. Donnay, Johns Hopkins University; Helen M. Ondik, National Bureau of Standards; Sten Samson, California Institute of Technology; Quintin Johnson, Lawrence Radiation Laboratory; Melvin H. Mueller, Argonne National Laboratory; Gerard M. Wolten, Aerospace Corporation; Mary E. Mrose, U.S. Geological Survey; Olga Kennard and David G. Watson, Cambridge University, England; and Murray Vernon King, Massachusetts General Hospital.

The Third Edition of Crystal Data will be available in the very near future. For further information and price schedules, please write directly to:

Joint Committee on  
Powder Diffraction Standards  
1601 Park Lane  
Swarthmore, Pennsylvania  
19081

<sup>1</sup> Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

<sup>2</sup> IUPAC Information Bulletin Appendix No. 2, December 1969, *Catalog of Physicochemical Standard Substances*, p. 17, Commission on Physicochemical Measurements and Standards (Chairman: D. R. Stull), Division of Physical Chemistry, IUPAC.

#### Firefighters' Continued

questions, the Bureau is presently performing laboratory tests and is in the process of constructing a full-scale test facility in cooperation with the District of Columbia Fire Department. The full-scale facility will permit environments to be established that realistically simulate actual fire conditions. Instru-

mentation will monitor heat flows and temperature gradients. Initially, full-size mannequins will be instrumented for tests on protective clothing. In later tests, live firefighters could participate as subjects. The purpose of these full-scale tests is not to evaluate each and every turn-out coat but rather to develop the principles of fire-coat design. With a complete un-

derstanding of protective clothing performance under firefighting conditions, it should be possible to predict the performance of new designs and materials. It is also anticipated that criteria will be evolved that will lead to specification of meaningful performance requirements for firefighters' protective clothing.

<sup>1</sup> The Fire Research and Safety Act of 1968, Public Law 90-259.

# PUBLICATIONS of the National Bureau of Standards\*

## PERIODICALS

*Technical News Bulletin*, Annual subscription: Domestic, \$3; foreign, \$4. Single copy price 30 cents. Available on a 1-, 2-, or 3-year subscription basis. SD Catalog No. C13.13:55.

*Journal of Research of the National Bureau of Standards*

*Section A. Physics and Chemistry*. Issued six times a year. Annual subscription: Domestic, \$9.50; foreign, \$11.75. Single copy price varies. SD Catalog No. C13.22/sec.A:74.

*Section B. Mathematical Sciences*. Issued quarterly. Annual subscription: Domestic, \$5; foreign, \$6.25. Single copy, \$1.25. SD Catalog No. C13.22/sec.B:74.

*Section C. Engineering and Instrumentation*. Issued quarterly. Annual subscription: Domestic, \$6; foreign, \$6.25. Single copy, \$1.25. SD Catalog No. C13.22/sec.C:74.

## CURRENT ISSUES OF THE JOURNAL OF RESEARCH

*J. Res. Nat. Bur. Stand. (U.S.)*, **75A6**, (*Phys. & Chem.*), (November-December 1971). SD Catalog No. C13.22/sec.A:75/6.

Cezairliyan, A., High-speed (subsecond) measurement of heat capacity, electrical resistivity, and thermal radiation properties of niobium in the range 1500 to 2700 K.

Fatiadi, A. J., Stable radical-anions derived from glyoxal bis(phenylhydrazones).

Lias, S. G., and Ausloos, P., Isomerization processes in ions of the empirical formula  $C_2H_5^+$ .

Marinenko, G., and Foley, R. T., A new determination of the atomic weight of zinc.

Marvin, R. S., The accuracy of measurements of viscosity of liquids.

Penn, R. W., and Kearsley, E. A., An absolute determination of viscosity using channel flow.

Rebber, R. E., Lias, S. G., and Ausloos, P., The photochemistry of propane at high photon energies (8.4 - 21.2 eV).

Scharf, K., and Mohr, R. K., Temperature dependence of photocurrents produced by x and gamma rays in silicon radiation detectors.

White, H. S., and Kearsley, E. A., An absolute determination of viscosity using a torsional pendulum.

## OTHER NBS PUBLICATIONS

Bullis, W. M., Editor, Methods of measurement for semiconductor materials, process control, and devices, Quarterly Report October 1 to December 31, 1970. Nat. Bur. Stand. (U.S.), Tech. Note 592, 72 pages (Aug. 1971) 70 cents. SD Catalog No. C13.46:592.

Cornog, J. R., Buntun, E. D., U.S. Metric Study Interim Report: Nonmanufacturing businesses. Nat. Bur. Stand. (U.S.), Spec. Publ. 345-5, 200 pages (July 1971) \$1.50. SD Catalog No. C13.10:345-5.

Dean, J. W., Brennan, J. A., Mann, D. B., Kneebone, C. H., Cryogenic flow research facility provisional accuracy statement. Nat. Bur. Stand. (U.S.), Tech. Note 606, 40 pages (July 1971) 45 cents. SD Catalog No. C13.46:606.

DeSimone, D. V., A Metric America: A decision whose time has come. Nat. Bur. Stand. (U.S.), Spec. Publ. 345, 184 pages (July 1971) \$2.25. SD Catalog No. C13.10:345.

Gordon, G. F., U.S. Metric Study Interim Report: International trade. Nat. Bur. Stand. (U.S.), Spec. Publ. 345-8, 188 pages (July 1971) \$1.50. SD Catalog No. C13.10:345-8.

McCarty, R. D., Weber, L. A., Thermophysical properties of oxygen from the freezing liquid line to 600 R for pressures to 5000 psia. Nat. Bur. Stand. (U.S.), Tech. Note 384, 189 pages (July 1971) \$1.50. SD Catalog No. C13.46:384.

Robinson, B. D., U.S. Metric Study Interim Report: Education. Nat. Bur. Stand. (U.S.), Spec. Publ. 345-6, 216 pages (July 1971) \$1.75. SD Catalog No. C13.10:345-6.

Smith, R. V., Steam-water, critical flow in a venturi. Nat. Bur. Stand. (U.S.), Tech. Note 608, 25 pages (July 1971) 35 cents. SD Catalog No. C13.46:608.

White, H. S., Jr., Metropolitan Statistical Areas. Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 8-1, 7 pages (1971) 10 cents. SD Catalog No. C13.52:8-1. Supersedes FIPS PUB 8, June 9, 1969.

## PUBLICATIONS IN OTHER JOURNALS

*This column lists all outside publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.*

Noack, M., Kokoszka, G. F., Gordon, G., Dynamic Jahn-Teller effects and magnetic

anisotropies in aqueous solutions and water-ethanol glasses of copper(II) solvates and complexes with 2,2'-dipyridine. *J. Chem. Phys.* **54**, No. 3, 1342-1350 (Feb. 1, 1971).

Olson, W. B., Papousek, D., High-resolution infrared spectra of ethanolic molecules and the barrier to internal rotation: The  $\nu_{9,113}$  band of dimethylacetylene. *J. Mol. Spectry.* **37**, No. 3, 527-534 (Mar. 1971).

Otoshi, T. Y., Stelzried, C. T., Yates, B. C., Beatty, R. W., Comparisons of waveguide losses calibrated by the DC potentiometer, AC ratio transformer, and reflectometer techniques. *IEEE Trans. Microwave Theory Tech.* **MTT-18**, No. 7, 406-409 (July 1970).

Parker, H. S., Harding, C. A., Vapor growth of  $Al_2O_3$  bicrystals. *J. Am. Ceram. Soc.* **53**, No. 11, 583-585 (November 11, 1970).

Parker, R. L., Crystal growth mechanisms: Energetics, kinetics, and transport. *Solid State Phys.* **25**, 151-299 (Academic Press, Inc., New York, N.Y., 1970).

Pecker, J. C., Thomas, R. N., Personal libraries and publication policies. *Atoms* **25**, 37-38 (Jan. 1970).

Pella, P. A., DeVoe, J. R., The determination of tin in copper-base alloys by Mössbauer spectrometry. *Anal. Chem.* **42**, No. 14, 1833-1835 (December 1970).

Perel, J., Deslattes, R. D., Extended fine-structure in x-ray absorption spectra of certain perovskites. *Phys. Rev. B* **2**, No. 5, 1317-1323 (Sept. 1970).

Plante, E. R., Paule, R. C., Explanation of the  $H^+$  vs  $S^+$  correlation. *J. Chem. Phys.* **53**, No. 9, 3770-3771 (November 1, 1970).

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